Dr. BENJ. FRANKLIN

ON THE

CAUSES AND CURE

OF

SMOKY CHIMNEYS.

[Price Two Shillings.]

OBSERVATIONS
ON THE
CAUSES AND CURE
OF
SMOKY CHIMNEYS.

BY HIS EXCELLENCY
BENJAMIN FRANKLIN, LL.D. F.R.S.
PRESIDENT OF THE STATE OF PENNSYLVANIA, AND OF
THE AMERICAN PHILOSOPHICAL SOCIETY, &c.

IN A
LETTER TO DR. INGEN-HOUSZ,
PHYSICIAN TO THE EMPEROR, AT VIENNA.

ILLUSTRATED BY A COPPER-PLATE.

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D^r. Franklin *on* Smoky Chimneys.

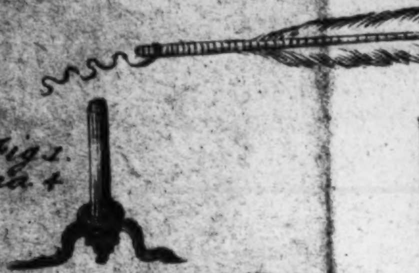


Fig.1. pa.4

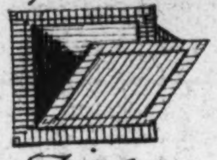


Fig.2. pa.13

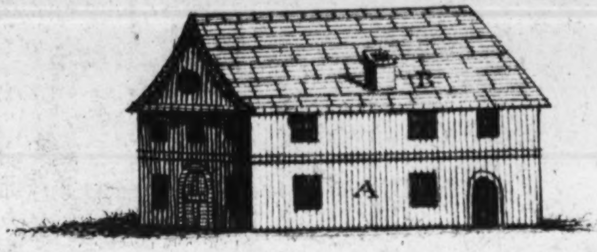
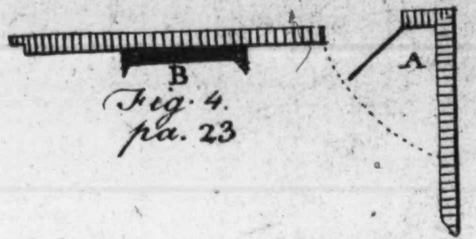


Fig.3. pa.22



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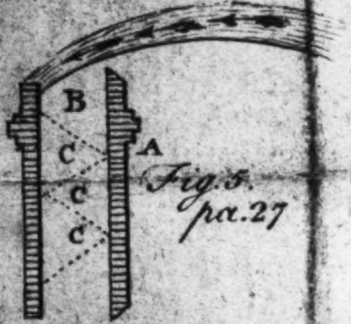
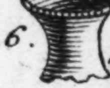


Fig.5. pa.27



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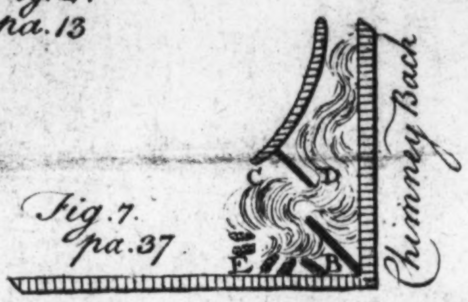


Fig.7. pa.37

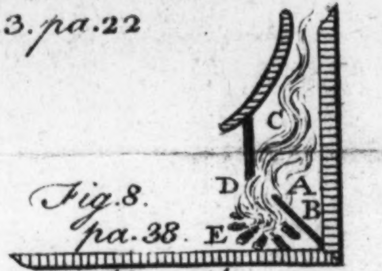


Fig.8. pa.38.

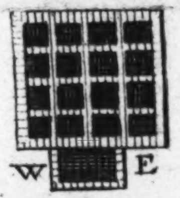


Fig.12. pa.55

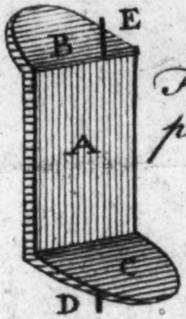


Fig.13. pa.55

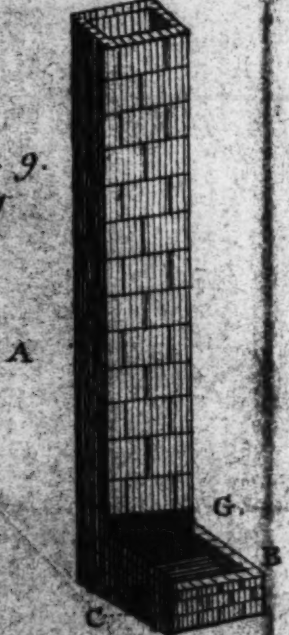
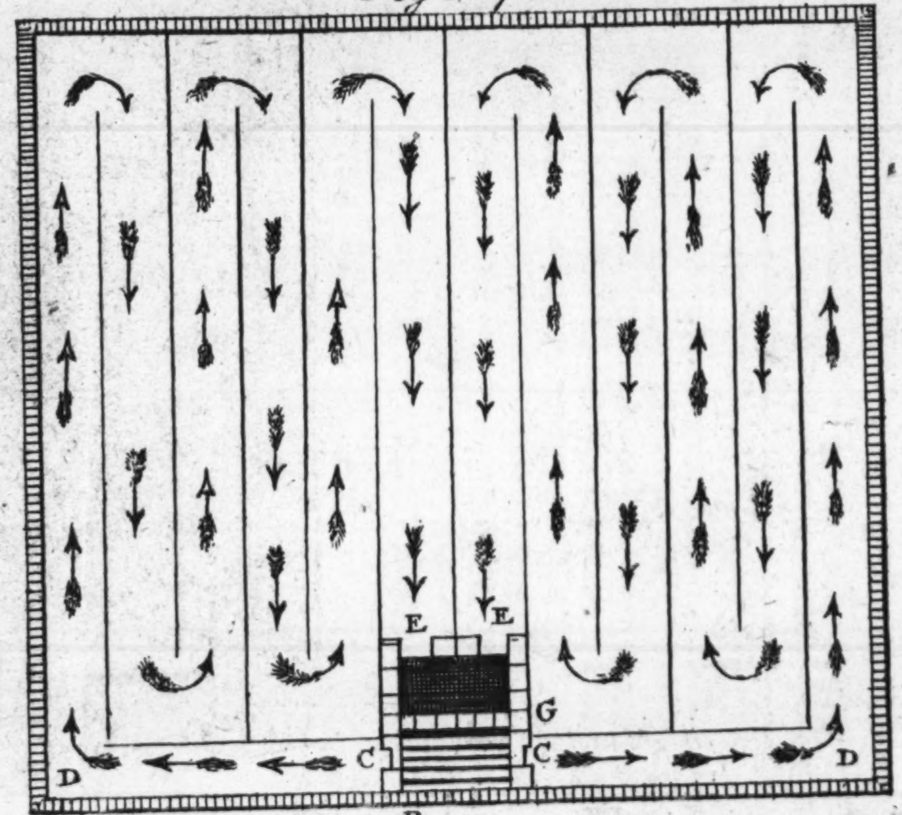


Fig.9. pa.61

Fig 10 pa.52



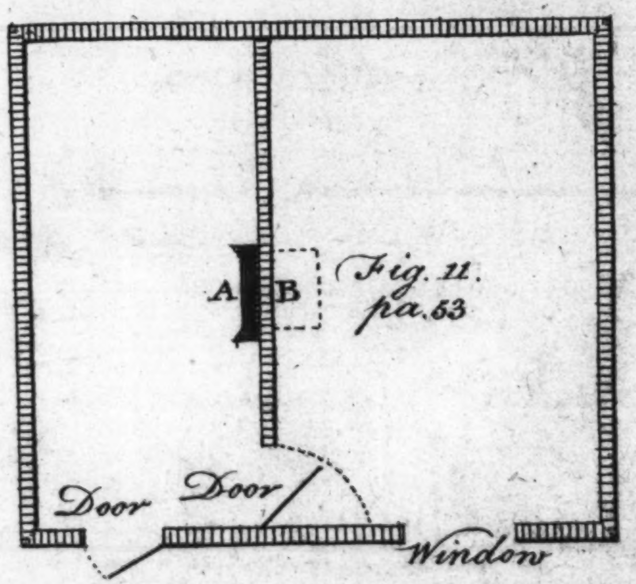


Fig.11. pa.53

A
LETTER, &c.

At Sea, Aug. 28, 1785.

DEAR FRIEND,

IN one of your letters, a little before I left France, you deſire me to give you, in writing, my thoughts upon the Conſtruction and Uſe of Chimneys; a ſubject you had ſometimes heard me touch upon in converſation. I embrace willingly this leiſure afforded by my preſent ſituation, to comply with your requeſt, as it will not only ſhew my regard to the deſires of a friend, but may at the ſame time be of ſome utility to others; the doctrine of chimneys appearing not to be as yet generally well underſtood, and miſtakes reſpecting them being attended with conſtant inconvenience, if not remedied; and with fruitleſs expence, if the true remedies are miſtaken.

Thoſe who would be acquainted with this ſubject, ſhould begin by conſidering on what principle ſmoke aſcends in any chimney. At firſt, many are apt to think that ſmoke is in its nature and of itſelf ſpecifically lighter than air, and riſes in it for the ſame reaſon that cork riſes in water. Theſe ſee no cauſe why ſmoke ſhould not riſe in the chimney, though the room be ever ſo cloſe. Others think there is a power in chimneys to draw up the ſmoke, and that there are different forms of chimneys which afford more or leſs of this power: theſe amuſe themſelves with ſearching for the beſt form. The equal dimenſions of a funnel in its whole length is not thought artificial enough, and it is made for fancied reaſons ſometimes tapering and narrowing from below upwards, and ſometimes the contrary, &c. &c. A ſimple experiment or two may ſerve to give more correct ideas. Having lit a pipe of tobacco, plunge the ſtem to the bottom of a decanter half filled with cold water; then putting a rag over the bowl, blow through it, and make the ſmoke deſcend in the ſtem of the pipe, from the end of which it will riſe in bubbles through the water; and being thus cooled will not afterwards riſe to go out through the neck of the decanter, but remain ſpreading itſelf, and reſting on the ſurface of the water. This ſhews that ſmoke is really heavier than air; and that it is carried upwards only when attached to, or acted upon, by air that is heated, and thereby rarefied and rendered ſpecifically lighter than the air in its neighbourhood.

Smoke being rarely ſeen but in company with heated air, and its upward motion being viſible, though that of the rarefied air that drives it is not ſo, has naturally given riſe to the error.

I need not explain to you, my learned friend, what is meant by rarefied air; but if you make the public uſe you propoſe of this letter, it may fall into the hands of ſome who are unacquainted with the term, and with the thing. Theſe then may be told, that air is a fluid which has weight as well as others, though about eight hundred times lighter than water; that heat makes the particles of air recede from each other and take up more ſpace, ſo that the ſame weight of air heated will have more bulk than equal weights of cold air which may ſurround it, and in that caſe muſt riſe, being forced upwards by ſuch colder and heavier air, which preſſes to get under it, and take its place. That air is ſo rarefied or expanded by heat, may be proved to their comprehenſion by a lank blown bladder, which laid before a fire will ſoon ſwell, grow tight, and burſt.

Another experiment may be, to take a glaſs tube, about an inch in diameter and twelve inches long, open at both ends, and fixed upright on legs, ſo that it need not be handled, for the hands might warm it: at the end of a quill, faſten five or ſix inches of the fineſt light filament of ſilk, ſo that it may be held either above the upper end of the tube or under the lower end, your warm hand being at a diſtance by the length of the quill. If there were any motion of air through the tube, it would manifeſt itſelf by its effect on the ſilk; but if the tube and the air in it are of the ſame temperature with the ſurrounding air, there will be no ſuch motion, whatever may be the form of the tube, whether crooked or ſtrait, narrow below and widening upwards, or the contrary; the air in it will be quieſcent. Warm the tube, and you will find as long as it continues warm, a conſtant current of air entering below and paſſing up through it, till diſcharged at the top; becauſe the warmth of the tube, being communicated to the air it contains, rarefies that air, and makes it lighter than the air without, which therefore preſſes in below, forces it upwards, follows and takes its place, and is rarefied in its turn. And without warming the tube, if you hold under it a knob of hot iron, the air thereby heated will riſe and fill the tube, going out at its top; and this motion in the tube will continue as long as the knob remains hot, becauſe the air entering the

Figure 1.

tube below is heated and rarefied by paſſing near and over that knob.

That this motion is produced merely by the difference of ſpecific gravity between the fluid within and that without the tube, and not by any fancied form of the tube itſelf, may appear by plunging it into water contained in a glaſs jar, a foot deep, through which ſuch motion might be ſeen. The water within and without the tube being of the ſame ſpecific gravity balance each other, and both remain at reſt. But take out the tube, ſtop its bottom with a finger, and fill it with olive oil, which is lighter than water, then ſtopping the top, place it as before, its lower end under water, its top a very little above; as long as you keep the bottom ſtopt, the fluids remain at reſt; but the moment it is unſtopt, the heavier enters below, forces up the lighter, and takes its place: and the motion then ceaſes, merely becauſe the new fluid cannot be ſucceſſively made lighter, as air may be by a warm tube.

In fact, no form of the funnel of the chimney has any ſhare in its operation or effect reſpecting ſmoke, except its height. The longer the funnel if erect, the greater its force when filled with heated and rarefied air, to draw in below and drive up the ſmoke (if one may in compliance with cuſtom uſe the expreſſion *draw)*, when in fact it is the ſuperior weight of the ſurrounding atmoſphere that preſſes to enter the funnel below, and ſo drives up before it the ſmoke and warm air it meets with in its paſſage.

I have been the more particular in explaining theſe firſt principles, becauſe for want of clear ideas reſpecting them, much fruitleſs expence has been occaſioned; not only ſingle chimneys, but in ſome inſtances, within my knowledge, whole ſtacks having been pulled down and rebuilt with funnels of different forms, imagined more powerful in drawing ſmoke, but having ſtill the ſame height and the ſame opening below, have performed no better than their predeceſſors.

What is it then which makes a ſmoky chimney; that is, a chimney which, inſtead of conveying up all the ſmoke, diſcharges a part of it into the room, offending the eyes and damaging the furniture?

The cauſes of this effect which have fallen under my obſervation, amount to nine, differing from each other, and therefore requiring different remedies.

I. Smoky chimneys in a new houſe are ſuch frequently from mere want of air. The workmanſhip of the rooms being all good and juſt out of the workman's hand, the joints of the boards of the flooring, and of the pannels of wainſcotting are all true and tight; the more ſo as the walls, perhaps not yet thoroughly dry, preſerve a dampneſs in the air of the room, which keeps the wood-work ſwelled and cloſe. The doors and the ſaſhes too, being worked with truth, ſhut with exactneſs: ſo that the room is as tight as a ſnuff-box, no paſſage being left open for air to enter, except the key-hole, and even that is ſometimes covered by a little dropping ſhutter. Now, if ſmoke cannot riſe but as connected with rarefied air, and a column of ſuch air, ſuppoſe it filling the funnel, cannot riſe, unleſs other air be admitted to ſupply its place; and if therefore no current of air enter the opening of the chimney, there is nothing to prevent the ſmoke coming out into the room. If the motion upwards of the air in a chimney that is freely ſupplied be obſerved by the riſing of the ſmoke or a feather in it, and it be conſidered that in the time ſuch feather takes in riſing from the fire to the top of the chimney, a column of air, equal to the content of the funnel, muſt be diſcharged, and an equal quantity ſupplied from the room below; it will appear abſolutely impoſſible that this operation ſhould go on if the tight room is kept ſhut: for were there any force capable of drawing conſtantly ſo much air out of it, it muſt ſoon be exhauſted, like the receiver of an air-pump, and no animal could live in it. Thoſe therefore who ſtop every crevice in a room to prevent the admiſſion of freſh air, and yet would have their chimney carry up the ſmoke, require inconſiſtencies, and expect impoſſibilities. Yet, under this ſituation, I have ſeen the owner of a new houſe in deſpair, and ready to ſell it for much leſs than it coſt, conceiving it uninhabitable, becauſe not a chimney in any one of its rooms would carry off the ſmoke, unleſs a door or window were left open. Much expence has alſo been made to alter and amend new chimneys which had really no fault: in one houſe particularly that I knew, of a nobleman in Weſtminſter, that expence amounted to no leſs than three hundred pounds, after his houſe had been, as he thought, finiſhed, and all charges paid; and after all, ſeveral of the alterations were ineffectual, for want of underſtanding the true principles.

Remedies. When you find on trial that opening the door or a window enables the chimney to carry up all the ſmoke, you may be ſure that want of air from without was the cauſe of its ſmoking: I ſay *from without*, to guard you againſt a common miſtake of thoſe who may tell you, the room is large, contains abundance of air ſufficient to ſupply any chimney, and therefore it cannot be that the chimney wants air. Theſe reaſoners are ignorant, that the largeneſs of a room, if tight, is in this caſe of ſmall importance, ſince it cannot part with a chimneyful of its air, without occaſioning ſo much vacuum; which it requires a great force to effect, and could not be borne if effected.

It appearing plainly, then, that ſome of the outward air muſt be admitted, the queſtion will be, How much is abſolutely neceſſary? for you would avoid admitting more, as being contrary to one of your intentions in having a fire; viz. that of warming your room. To diſcover this quantity, ſhut the door gradually, while a middling fire is burning, till you find that before it is quite ſhut, the ſmoke begins to come out into the room; then open it a little, till you perceive the ſmoke comes out no longer: there hold the door, and obſerve the width of the open crevice between the edge of the door and the rabbit it ſhould ſhut into. Suppoſe the diſtance to be half an inch, and the door eight feet high, you find thence that your room requires an entrance for air equal in area to ninety-ſix half-inches, or forty-eight ſquare inches, or a paſſage of ſix inches by eight.

This, however, is a large ſuppoſition, there being few chimneys that, having a moderate opening and a tolerable height of funnel, will not be ſatisfied with ſuch a crevice of a quarter of an inch; and I have found a ſquare of ſix by ſix, or thirty-ſix ſquare inches, to be a pretty good medium, that will ſerve for moſt chimneys. High funnels, with ſmall and low openings, may indeed be ſupplied through a leſs ſpace; becauſe, for reaſons that will appear hereafter, the force of levity (if one may ſo ſpeak) being greater in ſuch funnels, the cool air enters the room with greater velocity, and conſequently more enters in the ſame time. This, however, has its limits; for experience ſhews, that no increaſed velocity ſo occaſioned has made the admiſſion of air through the key-hole equal in quantity to that through an open door, though through the door the current moves ſlowly, and through the key-hole with great rapidity.

It remains then to be conſidered, how and where this neceſſary quantity of air from without is to be admitted, ſo as to be leaſt inconvenient. For, if at the door, left ſo much open, the air thence proceeds directly to the chimney, and, in its way, comes cold to your back and heels, as you ſit before your fire; if you keep the door ſhut, and raiſe a little the ſaſh of your window, you feel the ſame inconvenience. Various have been the contrivances to avoid this: ſuch as bringing in freſh air through pipes, in the jams of the chimney, which, pointing upwards, ſhould blow the ſmoke up the funnel; opening paſſages into the funnel above, to let in air for the ſame purpoſe. But theſe produce an effect contrary to that intended; for, as it is the conſtant current of air paſſing from the room through the opening of the chimney into the funnel, which prevents the ſmoke coming out into the room, if you ſupply the funnel by other means, or in other ways, with the air it wants, and eſpecially if that air be cold, you diminiſh the force of that current, and the ſmoke, in its efforts to enter the room, finds leſs reſiſtance.

The wanted air muſt then indiſpenſibly be admitted into the room to ſupply what goes off through the opening of the chimney. M. Gauger, a very ingenious and intelligent French writer on the ſubject, propoſes, with judgment, to admit it above the opening of the chimney; and to prevent inconvenience from its coldneſs, he directs its being made to paſs in its entrance through winding cavities made behind the iron back and ſides of the fire-place, and under the iron hearth-plate; in which cavities it will be

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In all rooms where there is a fire, the body of air warmed and rarefied before the chimney is continually changing place, and making room for other air, that is to be warmed in its turn: part of it enters and goes up the chimney, and the reſt riſes and takes place near the ceiling. If the room be lofty, that warm air remains above our heads as long as it continues warm, and we are little benefited by it, becauſe it does not deſcend till it is cooler. Few can imagine the difference of climate between the upper and lower parts of ſuch a room, who have not tried it by the thermometer, or by going up a ladder till their heads are near the ceiling. It is then among this warm air that the wanted quantity of outward air is beſt admitted, with which being mixed, its coldneſs is abated, and its inconvenience diminiſhed, ſo as to become ſcarce obſervable. This may be eaſily done by drawing down about an inch the upper ſaſh of a window; or, if not moveable, by cutting ſuch a crevice through its frame; in both which caſes it will be well to place a thin ſhelf of the length, to conceal the opening; and ſloping upwards, to direct the entering air horizontally along and under the ceiling. In ſome houſes, the air may be admitted by ſuch a crevice made in the wainſcot, cornice, or plaiſtering, near the ceiling and over the opening of the chimney. This, if practicable, is to be choſen; becauſe the entering cold air will there meet with the warmeſt riſing air from before the fire, and be ſooneſt tempered by the mixture. The ſame kind of ſhelf ſhould alſo be placed here. Another way, and not a very difficult one, is to take out an upper pane of glaſs in one of your ſaſhes: ſet it in a tin frame, giving it two ſpringing angular ſides, and then replacing it with hinges below, on which it may be turned to open more or leſs above. It will then have the appearance of an internal ſky-light. By drawing this pane in more or leſs, you may admit what air you

Figure 2.

find neceſſary. Its poſition will naturally throw that air up and along the ceiling. This is what is called in France a *Was iſt das?* As this is a German queſtion, the invention is probably of that nation, and takes its name from the frequent aſking of that queſtion when it firſt appeared. In England, ſome have of late-years cut a round hole, about five inches diameter, in a pane of the ſaſh, and placed againſt it a circular plate of tin, hung on an axis, and cut into vanes, which being ſeparately bent a little obliquely, are acted upon by the entering air, ſo as to force the plate continually round, like the vanes of a windmill.— This admits the outward air, and by the continual whirling of the vanes, does in ſome degree diſperſe it. The noiſe only is a little inconvenient.

II. A ſecond cauſe of the ſmoking of chimneys is, their openings in the room being too large; that is, too wide, too high, or both. Architects in general have no other ideas of proportion in the opening of a chimney, than what relate to ſymmetry and beauty, reſpecting the dimenſions of the room *; while its true proportion, reſpecting its function and utility, depends on quite other principles; and they might as properly proportion the ſtep in a ſtair caſe to the height of the ſtory, inſtead of the natural elevation of men's legs in mounting. The proportion then to be regarded, is what relates to the height of the funnel. For as the funnels in the different ſtories of a houſe are neceſſarily of different heights or lengths, that from the loweſt floor being the higheſt or longeſt, and thoſe of the other floors ſhorter and ſhorter, till we come to thoſe in the garrets, which are of courſe the ſhorteſt; and the force of draft being, as already ſaid, in proportion to the height of funnel filled with rarefied air; and a current of air from the room into the chimney, ſufficient to fill the opening, being neceſſary to oppoſe and prevent the ſmoke coming out into the room; it follows, that the openings of the longeſt funnels may be larger, and that thoſe of the ſhorter funnels ſhould be ſmaller. For if there be a large opening to a chimney that does not draw ſtrongly, the funnel may happen to be furniſhed with the air it demands by a partial current entering on one ſide of the opening, and, leaving the other ſide free of any oppoſing current, may permit the ſmoke to iſſue there into the room. Much too of the force of draft in a funnel depends on the degree of rarefaction in the air it contains; and that depends on the nearneſs to the fire of its paſſage in entering the funnel. If it can enter far from the fire on each ſide, or far above the fire in a wide or high opening, it receives little heat in paſſing by the fire, and the contents of the funnel is by that means leſs different in levity from the ſurrounding atmoſphere, and its force in drawing conſequently weaker. Hence if too large an opening be given to chimneys in upper rooms, thoſe rooms will be ſmoky. On the other hand, if too ſmall openings be given to chimneys in the lower rooms, the entering air operating too directly and violently on the fire, and afterwards ſtrengthening the draft as it aſcends the funnel, will conſume the fuel too rapidly.

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* See Appendix, No. I.

Remedy. As different circumſtances frequently mix themſelves in theſe matters, it is difficult to give preciſe dimenſions for the openings of all chimneys. Our fathers made them generally much too large: we have leſſened them; but they are often ſtill of greater dimenſion than they ſhould be, the human eye not being eaſily reconciled to ſudden and great changes. If you ſuſpect that your chimney ſmokes from the too great dimenſion of its opening, contract it by placing moveable boards ſo as to lower and narrow it gradually, till you find the ſmoke no longer iſſues into the room. The proportion ſo found will be that which is proper for that chimney, and you may employ the bricklayer or maſon to reduce it accordingly. However, as, in building new houſes, ſomething muſt be ſometimes hazarded, I would have the openings in my lower rooms about thirty inches ſquare and eighteen deep, and thoſe in the upper only eighteen inches ſquare and not quite ſo deep; the intermediate ones diminiſhing in proportion as the height of funnel diminiſhed. In the larger openings, billets of two feet long, or half the common length of cordwood, may be burnt conveniently; and for the ſmaller, ſuch wood may be ſawed into thirds. Where coals are the fuel, the grates will be proportioned to the openings. The ſame depth is nearly neceſſary to all, the funnels being all made of a ſize proper to admit a chimney-ſweeper. If in large and elegant rooms cuſtom or fancy ſhould require the appearance of a larger chimney, it may be formed of expenſive marginal decorations, in marble, &c. In time, perhaps, that which is fitteſt in the nature of things may come to be thought handſomeſt. But at preſent, when men and women in different countries ſhew themſelves diſſatisfied with the forms God has given to their heads, waiſts, and feet, and pretend to ſhape them more perfectly, it is hardly to be expected that they will be content always with the beſt form of a chimney. And there are ſome, I know, ſo bigotted to the fancy of a large noble opening, that, rather than change it, they would ſubmit to have damaged furniture, ſore eyes, and ſkins almoſt ſmoked to bacon.

III. Another cauſe of ſmoky chimneys is too ſhort a funnel. This happens neceſſarily in ſome caſes, as where a chimney is required in a low building; for if the funnel be raiſed high above the roof, in order to ſtrengthen its draft, it is then in danger of being blown down, and cruſhing the roof in its fall.

Remedies. Contract the opening of the chimney, ſo as to oblige all the entering air to paſs through or very near the fire; whereby it will be more heated and rarefied, the funnel itſelf be more warmed, and its contents have more of what may be called the force of levity, ſo as to riſe ſtrongly, and maintain a good draft at the opening.

Or you may, in ſome caſes, to advantage, build additional ſtories over the low building, which will ſupport a high funnel.

If the low building be uſed as a kitchen, and a contraction of the opening therefore inconvenient, a large one being neceſſary, at leaſt when there are great dinners, for the free management of ſo many cooking utenſils; in ſuch caſe I would adviſe the building of two more funnels, joining to the firſt, and having three moderate openings, one to each funnel, inſtead of one large one. When there is occaſion to uſe but one, the other two may be kept ſhut by ſliding plates, hereafter to * be deſcribed; and two, or all of them, may be uſed together, when wanted. This will indeed be an expence, but not an uſeleſs one; ſince your cooks will work with more comfort, ſee better than in a ſmoky kitchen what they are about; your victuals will be cleaner dreſſed, and not taſte of ſmoke, as is often the caſe: and to render the effect more certain, a ſtack of three funnels may be ſafely built higher above the roof than a ſingle funnel.

The caſe of too ſhort a funnel is more general than would be imagined, and often found where one would not expect it. For it is not uncommon in ill-contrived buildings, inſtead of having a funnel for each room, or fire-place, to bend and turn the funnel of an upper room, ſo as to make it enter the ſide of another funnel that comes from below. By this means the upper room funnel is made ſhort of courſe, ſince its length can only be reckoned from the place where it enters the

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* See Appendix, No. II.

lower room funnel; and that funnel is alſo ſhortened by all the diſtance between the entrance of the ſecond funnel and the top of the ſtack: for all that part being readily ſupplied with air through the ſecond funnel, adds no ſtrength to the draft, eſpecially as that air is cold when there is no fire in the ſecond chimney. The only eaſy remedy here is to keep the opening ſhut of that funnel in which there is no fire.

IV. Another very common cauſe of the ſmoking of chimneys is their overpowering one another. For inſtance, if there be two chimneys in one large room, and you make fires in both of them, the doors and windows cloſe ſhut, you will find that the greater and ſtronger fire ſhall overpower the weaker, and draw air down its funnel to ſupply its own demand; which air deſcending in the weaker funnel, will drive down its ſmoke, and force it into the room. If, inſtead of being in one room, the two chimneys are in two different rooms, communicating by a door, the caſe is the ſame whenever that door is open. In a very tight houſe, I have known a kitchen chimney on the loweſt floor, when it had a great fire in it, overpower any other chimney in the houſe, and draw air and ſmoke into its room, as often as the door was opened communicating with the ſtair-caſe.

Remedy. Take care that every room have the means of ſupplying itſelf from without with the air its chimney may require; ſo that no one of them may be obliged to borrow from another, nor under the neceſſity of lending.—A variety of theſe means have been already deſcribed.

V. Another cauſe of ſmoking is, when the tops of chimneys are commanded by higher buildings, or by a hill; ſo that the wind blowing over ſuch eminences falls like water over a dam, ſometimes almoſt perpendicularly on the tops of the chimneys that lie in its way, and beats down the ſmoke contained in them.

Remedy. That commonly applied to this caſe is a turn-cap made of tin or plate iron, covering the chimney above and on three ſides, open on one ſide, turning on a ſpindle, and which being guided or governed by a vane, always preſents its back to the current. This, I believe, may be generally effectual, though not certain, as there may be caſes in which it will not ſucceed. Raiſing your funnels, if practicable, ſo as their tops may be higher, or at leaſt equal with the commanding eminence, is more to be depended on: But the turning cap, being eaſier and cheaper, ſhould firſt be tried. If obliged to build in ſuch a ſituation, I would chuſe to place my doors on the ſide next the hill, and the backs of my chimlower room funnel; and that funnel is alſo ſhortened by all the diſtance between the entrance of the ſecond funnel and the top of the ſtack: for all that part being readily ſupplied with air through the ſecond funnel, adds no ſtrength to the draft, eſpecially as that air is cold when there is no fire in the ſecond chimney. The only eaſy remedy here is to keep the opening ſhut of that funnel in which there is no fire.

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VI. There is another caſe of command, the reverſe of that laſt mentioned; it is where the commanding eminence is farther from the wind than the chimney commanded.—To explain this a figure may be neceſſary.

Suppoſe then a building, whoſe ſide A happens to be expoſed to the wind, and forms a kind of dam againſt its progreſs; the air obſtructed by this dam will, like water, preſs and ſearch for paſſages through it; and finding the top of the chimney B below the top of the dam, it will force itſelf down that funnel, in order to get through by ſome door or window open on the other ſide of the building: and if there be a fire in ſuch chimney, its ſmoke is of courſe beat down, and fills the room.

Figure 3.

Remedy. I know of but one;—which is, to raiſe ſuch funnel higher than the roof, ſupporting it, if neceſſary, by iron bars: for a turn-cap, in this caſe, has no effect, the dammed up air preſſing down through it, in whatever poſition the wind may have placed its opening.

I know a city in which many houſes are rendered ſmoky by this operation. For their kitchens being built behind, and connected by a paſſage with the houſes, and the tops of the kitchen chimneys lower than the top of the houſes, the whole ſide of a ſtreet, when the wind blows againſt its back, forms ſuch a dam as above deſcribed; and the wind ſo obſtructed forces down thoſe kitchen chimneys, eſpecially when they have but weak fires in them, to paſs through the paſſage and houſe into the ſtreet. Kitchen chimneys ſo formed and ſituated have another inconvenience in ſummer: if you open your upper room windows for air, a light breeze blowing over your kitchen chimney towards the houſe, though not ſtrong enough to force down its ſmoke as aforeſaid, is ſufficient to waft it into your windows, and fill the rooms with it; which, beſides the diſagreeableneſs, damages your furniture.

VII. Chimneys, otherwiſe drawing well, are ſometimes made to ſmoke by the improper and inconvenient ſituation of a door. When the door and chimney are on the ſame ſide of the room, as in the Figure, if the door A, being in the corner, is made to open againſt

Figure 4.

the wall, which is common, as being there, when open, more out of the way; it follows, that, when the door is only opened in part, a current of air ruſhing in paſſes along the wall into and acroſs the opening of the chimney B, and flirts ſome of the ſmoke out into the room. This happens more certainly when the door is ſhutting, for then the force of the current is augmented, and becomes very inconvenient to thoſe who, warming themſelves by the fire, happen to ſit in its way.

The REMEDIES are obvious and eaſy. Either put an intervening ſcreen from the wall round great part of the fire-place; or, which is perhaps preferable, ſhift the hinges of your door, ſo as it may open the other way, and, when open, throw the air along the other wall.

VIII. A room that has no fire in its chimney, is ſometimes filled with ſmoke, which is received at the top of its funnel, and deſcends into the room. In a former paper *, I have already explained the deſcending currents of air in cold funnels; it may not be amiſs however to repeat here, that funnels without fires have an effect according to their degree of coldneſs or warmth, on the air that happens to be contained in them. The ſurrounding

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* See Appendix, No. II.

rounding atmoſphere is frequently changing its temperature. If, after a warm ſeaſon, the outward air ſuddenly grows cold, the empty warm funnels begin to draw ſtrongly upward; that is, they rarefy the air contained in them, which of courſe riſes, cooler air enters below to ſupply its place, is rarefied in its turn, and riſes; and this operation continues, till the funnel grows cooler, or the outward air warmer, or both, when the motion ceaſes. On the other hand, if, after a cold ſeaſon, the outward air ſuddenly grows warm, and of courſe lighter, the air contained in the cool funnels being heavier, deſcends into the room; and the warmer air which enters their tops, being cooled in its turn, and made heavier, continues to deſcend; and this operation goes on, till the funnels are warmed by the paſſing of warm air through them; or the air itſelf grows cooler. When the temperature of the air and of the funnels is nearly equal, the difference of warmth in the air between day and night is ſufficient to produce theſe currents, the air will begin to aſcend the funnels as the cool of the evening comes on, and this current will continue till perhaps nine or ten o'clock the next morning, when it begins to heſitate; and as the heat of the day approaches, it ſets downwards, and continues ſo till towards evening, when it again heſitates for ſome time, and then goes upwards conſtantly during the night, as before mentioned. Now when ſmoke iſſuing from the tops of neighbouring funnels, paſſes over the tops of funnels which are at the time drawing downwards, as they often are in the middle part of the day, ſuch ſmoke is of neceſſity drawn into theſe funnels, and deſcends with the air into the chamber.

The Remedy is to have a ſliding plate, hereafter deſcribed *, that will ſhut perfectly the offending funnel.

IX. Chimneys which generally draw well, do nevertheleſs ſometimes give ſmoke into the rooms, it being driven down by ſtrong winds paſſing over the tops of their funnels, though not deſcending from any commanding eminence. This caſe is moſt frequent where the funnel is ſhort, and the opening turned from the wind. It is the more grievous, when it happens to be a cold wind that produces the effect; becauſe when you moſt want your fire, you are ſometimes obliged to extinguiſh it. To underſtand this, it may be conſidered, that the riſing light air, to obtain a free iſſue from the funnel, muſt puſh out of its way, or

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* See Appendix, No. II.

oblige the air that is over it to riſe. In a time of calm, or of little wind, this is done viſibly; for we ſee the ſmoke that is brought up by that air, riſe in a column above the chimney. But when a violent current of air, that is a ſtrong wind, paſſes over the top of a chimney, its particles have received ſo much force, which keeps them in a horizontal direction, and follow each other ſo rapidly, that the riſing light air has not ſtrength ſufficient to oblige them to quit that direction, and move upwards to permit its iſſue. Add to this, that ſome of the current paſſing over that ſide of the funnel which it firſt meets with, viz. at A, having been compreſſed by the reſiſtance of the funnel, may expand itſelf over the flue, and ſtrike the interior oppoſite ſide at B; from whence it may be reflected downwards, and from ſide to ſide, in the direction of the pricked lines, c, c, c.

Figure 5.

Remedies. In ſome places, particularly in Venice, where they have not ſtacks of chimneys, but ſingle flues, the cuſtom is, to open, or widen, the top of the flue rounding in the true form of a funnel; which ſome think may prevent the effect juſt mentioned, for that the wind blowing over one of the edges into the funnel, may be ſlanted out again on the other

Figure 6.

ſide by its form. I have had no experience of this; but I have lived in a windy country, where the contrary is practiſed, the tops of the flues being narrowed inwards, ſo as to form a ſlit for the iſſue of the ſmoke, long as the breadth of the funnel, and only four inches wide. This ſeems to have been contrived on a ſuppoſition, that the entry of the wind would thereby be obſtructed; and perhaps it might have been imagined, that the whole force of the riſing warm air being condenſed, as it were, in the narrow opening, would thereby be ſtrengthened, ſo as to overcome the reſiſtance of the wind. This, however, did not always ſucceed; for, when the wind was at north-eaſt, and blew freſh, the ſmoke was forced down by fits into the room I commonly ſat in, ſo as to oblige me to ſhift the fire into another. The poſition of the ſlit of this funnel was indeed north-eaſt and ſouth-weſt: perhaps if it had lain acroſs the wind, the effect might have been different. But on this I can give no certainty: it ſeems a matter proper to be referred to experiment. Poſſibly a turn-cap might have been ſerviceable, but it was not tried.

Chimneys have not been long in uſe in England. I formerly ſaw a book, printed in the time of Queen Elizabeth, which remarked the then modern improvements of living, and mentioned, among others, the convenience of chimneys. "Our "forefathers," ſaid the author, "had no chimneys. "There was in each dwelling-houſe only one place "for a fire, and the ſmoke went out through a "hole in the roof; but now there is ſcarce a "gentleman's houſe in England that has not at "leaſt one chimney in it—" When there was but one chimney, its top might then be opened as a funnel, and perhaps, borrowing the form from the Venetians, it was then the flue of a chimney got that name. Such is now the growth of luxury, that, in both England and France, we muſt have a chimney for every room; and in ſome houſes, every poſſeſſor of a chamber, and almoſt every ſervant, will have a fire; ſo that the flues being neceſſarily built in ſtacks, the opening of each as a funnel is impracticable. This change of manners ſoon conſumed the fire-wood of England, and will ſoon render fuel extremely ſcarce and dear in France, if the uſe of coals be not introduced in the latter kingdom, as it has been in the former, where it at firſt met with oppoſition; for there is extant in the records of one of Queen Elizabeth's Parliaments, a motion made by a Member, reciting, "that many dyers, brewers, "ſmiths, and other artificers of London, had of

" late taken to the uſe of pitcoal for their fires,
" inſtead of wood; which filled the air with
" noxious vapours and ſmoke, very prejudicial
" to the health, particularly of perſons coming
" out of the country; and therefore moving, that
" a law might paſs, to prohibit the uſe of ſuch
" fuel (at leaſt during the ſeſſion of parliament)
" by thoſe artificers."—It ſeems it was not then commonly uſed in private houſes:—its ſuppoſed unwholeſomeneſs was an objection. Luckily the inhabitants of London have got over that objection; and now think it rather contributes to render their air ſalubrious, as they have had no general peſtilential diſorder ſince the general uſe of coals, when, before it, ſuch were frequent. Paris ſtill burns wood at an enormous expence continually augmenting, the inhabitants having ſtill that prejudice to overcome. In Germany you are happy in the uſe of ſtoves, which ſave fuel wonderfully: your people are very ingenious in the management of fire; but they may ſtill learn ſomething in that art from the Chineſe *; whoſe country being greatly populous, and fully cultivated, has little room left for the growth of wood, and having not much other fuel that is good, have been forced upon

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* See Appendix, No. III.

many inventions, during a courſe of ages, for making a little fire go as far as poſſible.

I have thus gone through all the common Cauſes of the Smoking of Chimneys that I can at preſent recollect as having fallen under my obſervation; communicating the remedies that I have known ſucceſsfully uſed for the different caſes, together with the principles on which both the diſeaſe and the remedy depend; and confeſſing my ignorance, wherever I have been ſenſible of it. You will do well, if you publiſh, as you propoſe, this letter, to add in notes, or as you pleaſe, ſuch obſervations as may have occurred to your attentive mind; and if other philoſophers will do the ſame, this part of ſcience, though humble yet of great utility, may in time be perfected. For many years paſt I have rarely met with a caſe of a ſmoky chimney, which has not been ſolvable on theſe principles, and cured by theſe remedies, where people have been willing to apply them; which is indeed not always the caſe; for many have prejudices in favour of the noſtrums of pretending chimney-doctors and fumiſts, and ſome have conceits and fancies of their own, which they rather chooſe to try, than to lengthen a funnel, alter the ſize of an opening, or admit air into a room, however neceſſary: for ſome are as much afraid of freſh air, as perſons in the hydrophobia are of freſh water. I myſelf had formerly this prejudice, this aërophobia, as I now account it, and dreading the ſuppoſed effects of cool air, I conſidered it as an enemy, and cloſed with extreme care every crevice in the rooms I inhabited. Experience has convinced me of my error:—I now look upon freſh air as a friend:—I even ſleep with an open window. I am perſuaded that no common air from without is ſo unwholeſome as the air within a cloſe room that has been often breathed and not changed. Moiſt air too, which formerly I thought pernicious, gives me now no apprehenſions: for conſidering that no dampneſs of air, applied to the outſide of my ſkin, can be equal to what is applied to and touches it within, my whole body being full of moiſture; and finding that I can lie two hours in a bath twice a week, covered with water, which certainly is much damper than any air can be, and this for years together, without catching cold, or being in any other manner diſordered by it;—I no longer dread mere moiſture, either in air, or in ſheets, or ſhirts: and I find it of importance to the happineſs of life, the being freed from vain terrors, eſpecially of objects that we are every day expoſed inevitably to meet with. You phyſicians have of late happily diſcovered, after a contrary opinion had prevailed ſome ages, that freſh and cool air does good to perſons in the ſmall-pox, and other fevers.—It is to be hoped that in another century or two we may all find out, that it is not bad even for people in health. And as to moiſt air,—here I am at this preſent writing, in a ſhip with above forty perſons, who have had no other but moiſt air to breathe for ſix weeks paſt; every thing we touch is damp, and nothing dries, yet we are all as healthy as we ſhould be on the mountains of Switzerland, whoſe inhabitants are not more ſo than thoſe of Bermuda or St. Helena, iſlands on whoſe rocks the waves are daſhed into millions of particles, which fill the air with damp, but produce no diſeaſes, the moiſture being pure, unmixed with the poiſonous vapours ariſing from putrid marſhes and ſtagnant pools, in which many inſects die and corrupt the water. Theſe places only, in my opinion, (which, however, I ſubmit to yours) afford unwholeſome air; and that it is not the mere water contained in damp air, but the volatile particles of corrupted animal matter mixed with that water, which renders ſuch air pernicious to thoſe who breathe it. And I imagine it a cauſe of the ſame kind that renders the air in cloſe rooms, where the perſpirable matter is breathed over and over again by a number of aſſembled people, ſo hurtful to health. After being in ſuch a ſituation, many find themſelves affected by that febricula which the Engliſh alone call a cold, and, perhaps from the name, imagine, that they caught the malady by going out of the room, when, in fact, it was by being in it.

You begin to think that I wander from my ſubject, and go out of my depth.—So I return again to my chimneys.

We have of late many lecturers in experimental philoſophy. I have wiſhed that ſome of them would ſtudy this branch of that ſcience, and give experiments in it as a part of their lectures. The addition to their preſent apparatus need not be very expenſive. A number of little repreſentations of rooms, compoſed each of five panes of ſaſh glaſs, framed in wood at the corners, with proportionable doors, and moveable glaſs chimneys, with openings of different ſizes, and different lengths of funnel, and ſome of the rooms ſo contrived as to communicate on occaſion with others, ſo as to form different combinations, and exemplify different caſes; with quantities of green wax taper cut into pieces of an inch and a half, ſixteen of which ſtuck together in a ſquare, and lit, would make a ſtrong fire for a little glaſs chimney, and, blown out, would continue to burn and give ſmoke as long as deſired: with ſuch an apparatus all the operations of ſmoke and rarefied air in rooms and chimneys might be ſeen through their tranſparent ſides; and the effect of winds on chimneys, commanded or otherwiſe, might be ſhewn by letting the entering air blow upon them through an opened window of the lecturer's chamber, where it would be conſtant while he kept a good fire in his chimney. By the help of ſuch lectures, our fumiſts would become better inſtructed.—At preſent they have generally but one remedy, which perhaps they have known effectual in ſome one caſe of ſmoky chimneys, and they apply that indiſcriminately to all the other caſes without ſucceſs,—but not without expence to their employers.

With all the ſcience, however, that a man ſhall ſuppoſe himſelf poſſeſſed of in this article, he may ſometimes meet with caſes that ſhall puzzle him.—I once lodged in a houſe at London, which, in a little room, had a ſingle chimney and funnel. The opening was very ſmall, yet it did not keep in the ſmoke; and all attempts to have a fire in this room were fruitleſs. I could not imagine the reaſon; till at length obſerving that the chamber over it, which had no fire-place in it, was always filled with ſmoke when a fire was kindled below, and that the ſmoke came through the cracks and crevices of the wainſcot, I had the wainſcot taken down, and diſcovered that the funnel which went up behind it, had a crack many feet in length, and wide enough to admit my arm ; a breach very dangerous with regard to fire, and occaſioned probably by an apparent irregular ſettling of one ſide of the houſe. The air entering this breach freely, deſtroyed the drawing force of the funnel.—The remedy would have been filling up the breach, or rather rebuilding the funnel : but the landlord rather choſe to ſtop up the chimney. Another puzzling caſe I met with at a friend's country-houſe near London.—His beſt room had a chimney in which, he told me, he never could have a fire, for all the ſmoke came out into the room. I flattered myſelf I could eaſily find the cauſe, and preſcribe the cure. I had a fire made there, and found it as he ſaid. I opened the door, and perceived it was not want of air.—I made a temporary contraction of the opening of the chimney, and found that it was not its being too large that cauſed the ſmoke to iſſue.—I went out, and looked up at the top of the chimney : its funnel was joined in the ſame ſtack with others, ſome of them ſhorter, that drew very well, and I ſaw nothing to prevent its doing the ſame : in fine, after every other examination I could think of, I was obliged to own the inſufficiency of my ſkill. But my friend, who made no pretenſion to ſuch kind of knowledge, afterwards diſcovered the cauſe himſelf. He got to the top of the funnel by a ladder, and looking down, found it filled with twiggs and ſtraw cemented by earth, and lined with feathers. It ſeems the houſe, after being built, had ſtood empty ſome years before he occupied it; and he concluded that ſome large birds had taken the advantage of its retired ſituation to make their neſt there. The rubbiſh, conſiderable in quantity, being removed, and the funnel cleared, the chimney drew well, and gave ſatisfaction. In general, ſmoke is a very tractable thing, eaſily governed and directed, when one knows the principles, and is well informed of the circumſtances. You know I make it deſcend in my Pennſylvania ſtove. I formerly had a more ſimple conſtruction, in which the ſame effect was produced, but viſible to the eye. It was compoſed of two plates, A B and C D, placed as in the Figure. The lower plate A B reſted with its edge in the angle made by the hearth with the back of the chimney. The upper plate was fixed to the breaſt, and lapt over the lower about ſix inches, leaving a ſpace of four inches wide, and the length of the plates (near

Figure 7.

(near two feet) between them. Every other paſſage of air into the funnel was well ſtopped. When therefore a fire was made at E, for the firſt time with charcoal, till the air in the funnel was a little heated through the plates, and then wood laid on, the ſmoke would riſe to A, turn over the edge of that plate, deſcend to D, then turn under the edge of the upper plate, and go up the chimney.—It was pretty to ſee, but of no great uſe. Placing, therefore, the under plate in a higher ſituation, I removed the upper plate C D, and placed it perpendicularly, ſo that the upper edge of the lower plate A B came within about three inches of it, and might be puſhed farther from it, or ſuffered to come nearer to it by a moveable wedge between them. The flame then aſcending from the fire at E, was carried to ſtrike the upper plate, made it very hot, and its heat roſe and ſpread with the rarefied air into the room. I believe you have ſeen in uſe with me the contrivance of a ſliding-plate over the fire, ſemingly placed to oppoſe the riſing of the ſmoke, leaving but a ſmall paſſage for it, between the edge of the plate and the back of the chimney. It is particularly deſcribed and its uſes explained in my former printed letter, and I mention it here only as another inſtance of the

Figure 8.

tractability of ſmoke *. What is called the Staffordſhire chimney, affords an example of the ſame kind.

The opening of the chimney is bricked up, even with the fore-edge of its jams, leaving open only a paſſage over the grate of the ſame width, and perhaps eight inches high. The grate conſiſts of ſemicircular bars, their upper bar of the greateſt diameter, the others under it ſmaller and ſmaller, ſo that it has the appearance of half a round baſket. It is, with the coals it contains, wholly without the wall that ſhuts up the chimney, yet the ſmoke bends and enters the paſſage above it, the draft being ſtrong, becauſe no air can enter that is not obliged to paſs near or through the fire; ſo that all that the funnel is filled with is much heated, and of courſe much rarefied.

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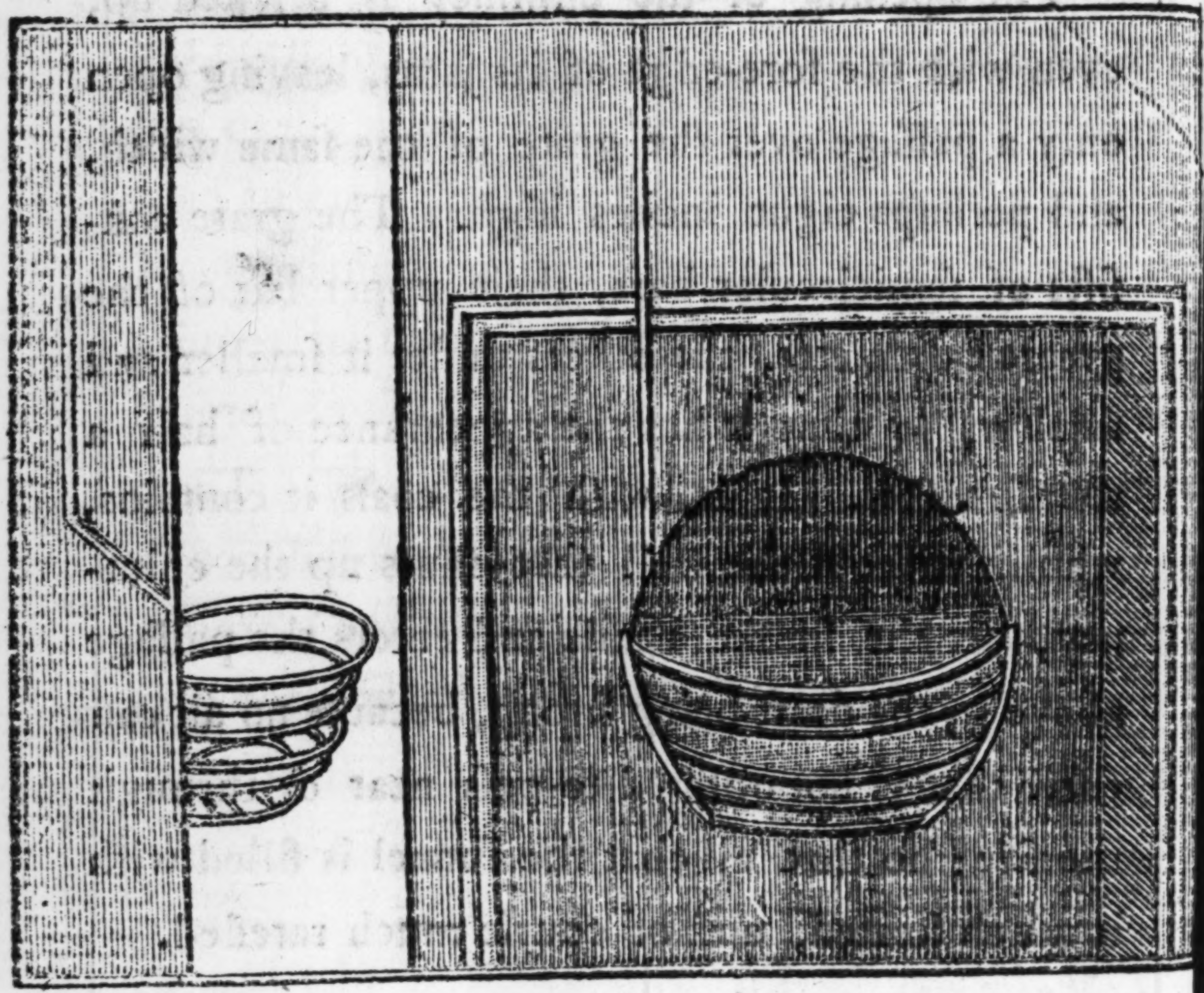
* See Appendix, No. II.

STAF-

STAFFORDSHIRE FIRE-PLACE.

Side View. Front View.



Much more of the proſperity of a winter country depends on the plenty and cheapneſs of fuel, than is generally imagined. In travelling, I have obſerved, that in thoſe parts where the inhabitants can have neither wood, nor coal, nor turf, but at exceſſive prices, the working-people live in miſerable hovels, are ragged, and have nothing comfortable about them. But where fuel is cheap, (or where they have the art of managing it to advantage), they are well furniſhed with neceſſaries, and have decent habitations. The obvious reaſon is, that the working hours of ſuch people are the profitable hours, and they who cannot afford ſufficient fuel, have fewer ſuch hours in the twenty-four, than thoſe who have it cheap and plenty; for much of the domeſtick work of poor women, ſuch as ſpinning, ſewing, knitting; and of the men in thoſe manufactures that require little bodily exerciſe, cannot well be performed where the fingers are numbed with cold. Thoſe people, therefore, in cold weather are induced to go to bed ſooner, and lie longer in the morning, than they would do, if they could have good fires or warm ſtoves to ſit by; and their hours of work are not ſufficient to produce the means of comfortable ſubſiſtence. Thoſe public works, therefore, ſuch as roads, canals, &c. by which fuel may be brought cheap into ſuch countries from diſtant places, are of great utility; and thoſe who promote them may be reckoned among the benefactors of mankind.

I have great pleaſure in having thus complied with your requeſt, and in the reflection that the friendſhip you honour me with, and in which I have ever been ſo happy, has continued ſo many years without the ſmalleſt interruption. Our diſtance from each other is now augmented, and nature muſt ſoon put an end to the poſſibility of my continuing our correſpondence: but if conſciouſneſs and memory remain in a future ſtate, my eſteem and reſpect for you, my dear friend, will be everlaſting.

B. F.

* * *

A P.

APPENDIX.

NOTES for the LETTER on CHIMNEYS.

No. I.

THE lateſt work on architecture that I have ſeen, is that entitled **NUTSHELLS**, which appears to be written by a very ingenious man, and contains a table of the proportions of the openings of chimneys; but they relate ſolely to the proportions he gives his rooms, without the ſmalleſt regard to the funnels; and he remarks reſpecting thoſe proportions, that they are ſimilar to the harmonic diviſions of a monochord*. He does not indeed lay much ſtreſs on this; but it ſhews that we like the appearance of principles; and where we have not true ones, we have ſome ſatisfaction in producing ſuch as are imaginary.

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* "It may be juſt remarked here, that upon comparing theſe proportions with thoſe ariſing from the common diviſions of the monochord, it happens that the firſt anſwers to uniſon; and although the ſecond is a diſcord, the third anſwers to the third minor, the fourth to the third major, the fifth to the fourth, the ſixth to the fifth, and the ſeventh to the octave."

Nutſhells, p. 85.

No. II.

THE deſcription of the ſliding plates here promiſed, and which have been ſince brought into uſe under various names, with ſome immaterial changes, is contained in a former letter to J. B. eſq. as follows:

To J. B. Eſq. at Boſton in New England.

DEAR SIR, London, Dec. 2, 1758.

I HAVE executed here an eaſy, ſimple contrivance, that I have long ſince had in ſpeculation, for keeping rooms warmer in cold weather than they generally are, and with leſs fire: it is this:—The opening of the chimney is contracted by brick-work faced with marble ſlabs, to about two feet between the jams, and the breaſt brought down to within about three feet of the hearth. —An iron frame is placed juſt under the breaſt, and extending quite to the back of the chimney, ſo that a plate of the ſame metal may ſlide horizontally backwards and forwards in the grooves on each ſide of the frame.

This plate is juſt ſo large as to fill the whole ſpace, and ſhut the chimney entirely when thruſt quite in, which is convenient when there is no fire. Drawing it out, ſo as to leave a ſpace between its further edge and the back, of about two inches, this ſpace is ſufficient for the ſmoke to paſs; and ſo large a part of the funnel being ſtopt by the reſt of the plate, the paſſage of warm air out of the room, up the chimney, is obſtructed and retarded, and by that means much cold air is prevented from coming in through crevices, to ſupply its place. This effect is made manifeſt three ways:—Firſt, when the fire burns briſkly in cold weather, the howling or whiſtling noiſe made by the wind, as it enters the room through the crevices, when the chimney is open as uſual, ceaſes as ſoon as the plate is ſlid in to its proper diſtance. Secondly, opening the door of the room about half an inch, and holding your hand againſt the opening near the top of the door, you feel the cold air coming in againſt your hand, but weakly, if the plate be in. Let another perſon ſuddenly draw it out, ſo as to let the air of the room go up the chimney, with its uſual freedom where chimneys are open, and you immediately feel the cold air ruſhing in ſtrongly. Thirdly, if ſomething be ſet againſt the door, juſt ſufficient, when the plate is in, to keep the door nearly ſhut, by reſiſting the preſſure of the air that would force it open; then, when the plate is drawn out, the door will be forced open by the increaſed preſſure of the outward cold air endeavouring to get in to ſupply the place of the warm air that now paſſes out of the room to go up the chimney. In our common open chimneys, half the fuel is waſted, and its effect loſt, the air it has warmed being immediately drawn off. Several of my acquaintance having ſeen this ſimple machine in my room, have imitated it in their houſes, and it ſeems likely to become pretty common. I deſcribe it thus particularly to you, becauſe I think it would be uſeful in Boſton, where firing is often dear. Mentioning chimneys puts me in mind of a property I formerly had occaſion to obſerve in them, which I have not found taken notice of by others: it is, that in the ſummer time, when no fire is made in the chimneys, there is nevertheleſs a regular draft of air through them; continually paſſing upwards, from about five or ſix o'clock in the afternoon, till eight or nine o'clock next morning, when the current begins to ſlacken and heſitate a little, for about half an hour, and then ſets as ſtrongly down again, which it continues to do till towards five in the afternoon, then ſlackens and heſitates as before, going ſometimes a little up, then a little down, till in about half an hour it gets into a ſteady upward current for the night, which continues till eight or nine the next day; the hours varying a little as the days lengthen and ſhorten, and ſometimes varying from ſudden changes in the weather; as if, after being long warm, it ſhould begin to grow cool about noon, while the air was coming down the chimney, the current will then change earlier than the uſual hour, &c. This property in chimneys I imagine we might turn to ſome account, and render improper, for the future, the old ſaying, "As uſeleſs as a chimney in ſummer." If the opening of the chimney, from the breaſt down to the hearth, be cloſed by a ſlight moveable frame or two, in the manner of doors, covered with canvas, that will let the air through, but keep out the flies; and another little frame ſet within upon the hearth, with hooks on which to hang joints of meat, fowls, &c, wrapt well in wet linen cloths, three or four fold; I am confident, that if the linen is kept wet, by ſprinkling it once a day, the meat would be ſo cooled by the evaporation carried on continually by means of the paſſing air, that it would keep a week or more in the hotteſt weather. Butter and milk might likewiſe be kept cool, in veſſels or bottles covered with wet cloths. A ſhallow tray, or keeler, ſhould be under the frame, to receive any water that might drip from the wetted cloths. I think, too, that this property of chimneys might, by means of ſmoke-jack vanes, be applied to ſome mechanical purpoſes, where a ſmall but pretty conſtant power only is wanted. If you would have my opinion of the cauſe of this changing current of air in chimneys, it is, in ſhort, as follows: In ſummer time there is generally a great difference in the warmth of the air at mid-day and mid-night, and of courſe a difference of ſpecific gravity in the air, as the more it is warmed the more it is rarefied. The funnel of a chimney being for the moſt part ſurrounded by the houſe, is protected, in a great meaſure, from the direct action of the ſun's rays, and alſo from the coldneſs of the night-air. It thence preſerves a middle temperature between the heat of the day and the coldneſs of the night. This middle temperature it communicates to the air contained in it. If the ſtate of the outward air be cooler than that in the funnel of the chimney, it will, by being heavier, force it to riſe, and go out at the top. What ſupplies its place from below, being warmed in its turn by the warmer funnel, is likewiſe forced up by the colder and weightier air below; and ſo the current is continued till the next day, when the ſun gradually changes the ſtate of the outward air, makes it firſt as warm as the funnel of the chimney can make it (when the current begins to heſitate), and afterwards warmer. Then the funnel being cooler than the air that comes into it, cools that air, makes it heavier than the outward air, of courſe it deſcends; and what ſucceeds it from above, being cooled in its turn, the deſcending current continues till towards the evening, when it again heſitates, and changes its courſe, from the change of warmth in the outward air, and the nearly remaining ſame middle temperature in the funnel. Upon this principle, if a houſe were built behind Beacon-hill, an adit carried from one of the doors into the hill horizontally, till it met with a perpendicular ſhaft ſunk from its top, it ſeems probable to me, that thoſe who lived in the houſe, would conſtantly, in the heat even of the calmeſt day, have as much cool air paſſing through the houſe, as they ſhould chooſe; and the ſame, though reverſed in its current, during the ſtilleſt night.

I think, too, this property might be made of uſe to miners; as where ſeveral ſhafts or pits are ſunk perpendicularly into the earth, communicating at bottom by horizontal paſſages, which is a common caſe, if a chimney of thirty or forty feet high were built over one of the ſhafts, or ſo near the ſhaft, that the chimney might communicate with the top of the ſhaft, all air being excluded but what ſhould paſs up or down by the ſhaft; a cona conſtant change of air would, by this means, be produced in the paſſages below, tending to ſecure the workmen from thoſe damps which ſo frequently incommode them. For the freſh air would be almoſt always going down the open ſhaft to go up the chimney, or down the chimney to go up the ſhaft. Let me add one obſervation more, which is, that if that part of the funnel of a chimney, which appears above the roof of a houſe, be pretty long, and have three of its ſides expoſed to the heat of the ſun ſucceſſively, viz. when he is in the eaſt, in the ſouth, and in the weſt, while the north ſide is ſheltered by the building from the cool northerly winds; ſuch a chimney will often be ſo heated by the ſun, as to continue the draft ſtrongly upwards, through the whole twenty-four hours, and often for many days together. If the outſide of ſuch a chimney be painted black, the effect will be ſtill greater, and the current ſtronger.

No. III.

IT is ſaid the northern Chineſe have a method of warming their ground-floors, which is ingenious. Thoſe floors are made of tiles a foot ſquare and two inches thick, their corners being ſupported by bricks ſet on end, that are a foot long and four inches ſquare; the tiles too join into each other, by ridges and hollows along their ſides. This forms a hollow under the whole floor, which on one ſide of the houſe has an opening into the air, where a fire is made, and it has a funnel riſing from the other ſide to carry off the ſmoke. The fuel is a ſulphurous pitcoal, the ſmell of which in the room is thus avoided, while the floor, and of courſe the room, is well warmed. But as the under-ſide of the floor muſt grow foul with ſoot, and a thick coat of ſoot prevents much of the direct application of the hot air to the tiles, I conceive that burning the ſmoke, by obliging it to deſcend through red coals, would in this conſtruction be very advantageous, as more heat would be given by the flame than by the ſmoke, and the floor being thereby kept free from ſoot, would be more heated with leſs fire. For this purpoſe, I would propoſe erecting the funnel cloſe to the grate, ſo as to have only an iron plate between the fire and the funnel; through which plate the air in the funnel being heated, it will be ſure to draw well, and force the ſmoke to deſcend, as in the Figure, where A is the funnel or chimney, B the grate on which the fire is placed, C one of the apertures through which the deſcending ſmoke is drawn into the

Figure 9.

channel D, of FIG. 10, along which channel it is conveyed by a circuitous route, as deſignated by the arrows, until it arrives at the ſmall aperture E, FIG. 10, through which it enters the funnel F. G, in both Figures, is the iron plate againſt which the fire is made, which being heated thereby, will rarefy the air in that part of the funnel, and cauſe the ſmoke to aſcend rapidly. The flame, thus divided from the grate to the right and left, and turning in paſſages, diſpoſed as in FIG. 13, ſo as that every part of the floor may be viſited by it before it enters the funnel F, by the two paſſages E, E, very little of the heat will be loſt, and a winter room thus rendered very comfortable.

No. IV.

Page 1. *Few can imagine, &c.*—It is ſaid the Icelanders have very little fuel, chiefly drift wood that comes upon their coaſt. To receive more advantage from its heat, they make their doors low, and have a ſtage round the room, above the door, like a gallery, wherein the women can ſit and work, the men read or write, &c. The roof being tight, the warm air is confined by it, and kept from riſing higher and eſcaping; and the cool air which enters the houſe when the door is opened, cannot riſe above the level of the top of the door, becauſe it is heavier than the warm air above the door, and ſo thoſe in the gallery are not incommoded by it. Some of our too lofty rooms might have a ſtage ſo conſtructed as to make a temporary gallery above, for the winter, to be taken away in ſummer. Sedentary people would find much comfort there in cold weather.

No. V.

Page 26. *Where they have the art of managing it, &c.*—In ſome houſes of the lower people among the northern nations of Europe, and among the poorer ſort of Germans in Pennſilvania, I have obſerved this conſtruction, which appears very advantageous: A is the kitchen with its chimney; B an iron ſtove in the ſtove room. In a corner of the chimney is a hole through the back into the ſtove, to put in fuel, and another hole above it to let the ſmoke of the ſtove come back into the chimney. As ſoon as the cooking is over, the brands in the kitchen chimney are put through the hole to ſupply the ſtove, ſo that there is ſeldom more than one fire burning at a time. In the floor over the ſtove-room is a ſmall trap-door, to let the warm air ariſe occaſionally into the chamber. Thus the whole houſe is warmed at little expence of wood,

Figure 11.

and the ſtove-room kept conſtantly warm; ſo that in the coldeſt winter nights they can work late, and feel the room ſtill comfortable when they riſe to work early. An Engliſh farmer in America, who makes great fires in large open chimneys, needs the conſtant employment of one man to cut and haul wood for ſupplying them; and the draft of cold air to them is ſo ſtrong, that the heels of his family are frozen, while they are ſcorching their faces, and the room is never warm; ſo that little ſedentary work can be done by them in winter. The difference in this article alone of œconomy ſhall, in a courſe of years, enable the German to buy out the Engliſhman, and take poſſeſſion of his plantation.

MISCELLANEOUS OBSERVATIONS.

CHIMNEYS whoſe funnels go up the north wall of a houſe, and are expoſed to the north winds, are not ſo apt to draw well as thoſe in a ſouth wall; becauſe, when rendered cold by thoſe winds, they draw downwards.

Chimneys encloſed in the body of a houſe are better than thoſe whoſe funnels are expoſed in cold walls.

Chimneys in ſtacks are apt to draw better than ſeparate funnels; becauſe the funnels that have conſtant fires in them, warm the others in ſome degree that have none.

One of the funnels in a houſe I once occupied, had a particular funnel joined to the ſouth ſide of the ſtack, ſo that three of its ſides were expoſed to the ſun in the courſe of the day, viz. the eaſt ſide E during the morning; the ſouth ſide S in the middle part of the day, and the weſt ſide W during the afternoon; while its north ſide was ſheltered by the ſtack from the cold winds. This funnel, which came from the ground-floor, and had a conſiderable height above the roof, was conſtantly in a ſtrong drawing ſtate day and night, winter and ſummer.

Figure 12.

Blacking of funnels expoſed to the ſun, would probably make them draw ſtill ſtronger.

In Paris I ſaw a fireplace ſo ingeniouſly contrived as to ſerve conveniently for two rooms, a bed-chamber and a ſtudy. The funnel over the fire was round. —The fire-place was of caſt iron, having an upright back A, and two horizontal ſemicircular plates B C; the whole ſo ordered as to turn on the pivots D E. The plate B always ſtopped

Figure 13.

ſtopped that part of the round funnel that was next to the room without fire, while the other half of the funnel over the fire was always open. By this means a ſervant in the morning could make a fire on the hearth C, then in the ſtudy, without diſturbing the maſter by going into his chamber; and the maſter, when he roſe, could, with a touch of his foot, turn the chimney on its pivots, and bring the fire into his chamber, keep it there as long as he wanted it, and turn it again, when he went out into his ſtudy. The room which had no fire in it, was alſo warmed by the heat coming through the back plate, and ſpreading in the room, as it could not go up the chimney.

FINIS.